

S P E C I F I C A T I O N

Docket No. 00-C-016

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN that I, Anthony M. Chiu, a citizen of the United States of America residing in the State of Texas, have invented new and useful improvements in a

**SURFACE MOUNT PACKAGE WITH INTEGRAL ELECTRO-STATIC CHARGE
DISSIPATING RING USING LEAD FRAME AS ESD DEVICE**

of which the following is a specification:

BACKGROUND OF THE INVENTION

1. Field of the Invention:

5 The present invention relates generally to packaging integrated circuit devices and in particular to providing electrical discharge properties to integrated circuit device packaging. Still more particularly, the present invention relates to forming a metal ring an integrated circuit from a
10 portion of a lead frame for the purpose of conducting electrostatic energy away from the integrated circuit.

2. Description of the Prior Art:

15 In conventional integrated circuits, electrostatic discharge (ESD) events typically enter the circuitry through the pad ring, which dissipates the charge before reaching the core. Some recently developed integrated circuits, however, must necessarily expose the core of the circuitry to ESD
20 events. Contemporary fingerprint sensors, for example, often include a two-dimensional array of sensing electrodes proximate to a sensing surface on which the finger is placed, with ridges and valleys on the finger skin detected by capacitance variations caused by the varying distance between
25 the skin surface and the sensor electrodes. The need for contact with the finger in order to detect fingerprint features necessitates exposure of the integrated circuit to electrostatic discharge events resulting from a finger touching the sensing surface.

30 The electrostatic charge which may be carried by a human body oftens fall within the range of several kilovolts or more. Typical electrostatic discharge protection circuits

have proven somewhat ineffective in safely dissipating such charges, which may provide sufficient energy to break through upper dielectric/passivation layer.

5 Additionally, integrated circuits which cannot be completely encapsulated--except for conductive leads to the circuit--during packaging (e.g., fingerprint sensors, optical sensors, and other circuit requiring that a portion of the integrated circuit remain exposed) are typically mounted
10 utilizing "Chip On Board" technology. The integrated circuits are mounted on a printed circuit board in an unencapsulated form, connected to the printed circuit board through the bond wires, then protected utilizing liquid encapsulation or silicon gel. Such mounting, which involves the use of gold
15 plating of the substrate, is much more expensive than conventional surface mounting of integrated circuits on a stamped lead frame. However, viable surface mounting of fingerprint sensors on lead frames has not yet been achieved.

20 It would be desirable, therefore, to provide a technique for surface mounting of fingerprint sensors on lead frames while providing adequate electrostatic discharge protection to the packaged integrated circuit.

SUMMARY OF THE INVENTION

5 In a packaged integrated circuit, electrostatic discharge protection is provided by portions of a lead frame on which the integrated circuit is mounted. The lead frame includes a die paddle on which an integrated circuit die is mounted, with plastic or epoxy material encapsulating exposed surfaces of the integrated circuit die except for a sensing surface, and supporting pins or leads formed from the lead frame. Portions of the lead frame extending from the die paddle are folded around sides of the encapsulated integrated circuit die and over, or adjacent to and level with, a peripheral upper surface of the encapsulated integrated circuit die to form an electrostatic discharge ring. The lead frame portions folded around the integrated circuit package are connected to ground through a ground pin, so that charge on a human finger touching the electrostatic discharge ring is dissipated to ground before the finger contacts a sensing surface of the integrated circuit. The portions of the lead frame which are folded around the encapsulated integrated circuit die may extend only around sides or side regions of the integrated circuit package not including pins or leads or, alternatively, may extend around all sides of the integrated circuit package and have openings where side regions of the integrated circuit package includes pins or leads.

BRIEF DESCRIPTION OF THE DRAWINGS

5 The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself however, as well as a preferred mode of use, and further objects and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings, wherein:

10 **Figures 1A-1E** depict various views of a packaged surface mount integrated circuit having an integral electrostatic discharge ring formed from lead frame portions in accordance with a preferred embodiment of the present invention;

15 **Figures 2A-2D** are various views of alternative designs for a packaged surface mount integrated circuit having an integral electrostatic discharge ring formed from lead frame portions in accordance with a preferred embodiment of the present invention;

20 **Figures 3A-3B** depict plan views of lead frame strips utilized in forming a packaged surface mount integrated circuit having an integral electrostatic discharge ring formed from lead frame portions in accordance with a preferred embodiment of the present invention; and

25 **Figures 4A-4C** are various views of a narrow-strip packaged integrated circuit with gull-wing leads and an integral electrostatic discharge ring formed from lead frame portions in accordance with a preferred embodiment of the present invention.

DETAILED DESCRIPTION

5 The following description details the structure, application and features of the present invention, but it will be understood by those of skill in the art that the scope of the invention is defined only by the issued claims, and not by any description herein. The process steps and structures described below do not form a complete process flow for manufacturing integrated circuit packages. The present invention can be practiced in conjunction with integrated circuit package fabrication techniques currently used in the art, and only so much of the commonly practiced process steps are included as are necessary for an understanding of the present invention. The figures showing portions of an integrated circuit package during fabrication are not necessarily drawn to scale, but instead are drawn so as to illustrate the important features of the invention.

20 With reference now to the figures, and in particular with reference to **Figures 1A through 1E**, various views of a packaged surface mount integrated circuit having an integral electrostatic discharge ring formed from a lead frame portion in accordance with a preferred embodiment of the present invention are depicted. **Figure 1A** depicts a plan view of the integrated circuit package 102, while **Figure 1B** depicts a side view, **Figure 1C** depicts a cross-sectional view taken at section lines A-A, **Figure 1D** depicts a back or bottom view, and **Figure 1E** depicts an isometric view. Packaged integrated circuit 102 in the exemplary embodiment includes an fingerprint sensor integrated circuit die 104 having a sensing surface 106 proximate to an array of sensor electrodes. A finger is placed on sensing surface 106 of packaged integrated

circuit 102 in order to detect the fingerprint; accordingly, sensing surface 106 must remain exposed and should not be encapsulated.

5 Integrated circuit die 104 is mounted on a stamped metal lead frame 108, affixed to lead frame 108 by an adhesive 110. A peripheral portion of the integrated circuit die 104, not including sensing surface 106, is encapsulated in a plastic or epoxy material 112 protecting the integrated circuit and wire
10 bonds 114 connecting the integrated circuit die 104 to pins 116 formed from a portion of the lead frame 108. Plastic or epoxy material 112 is formed by molding in accordance with the known art. A lead frame strip having several lead frames, each bearing an integrated circuit die and wire bonds
15 connecting the integrated circuit die to the respective lead frame, is mounted on the mold with the integrated circuit die and wire bonds received by a mold cavity. The mold cavity includes surfaces contacting the sensing surface 106 of each integrated circuit die to prevent plastic or epoxy
20 encapsulating material from adhering to the sensing surface. Plastic or epoxy material is then formed to encapsulate portions of the integrated circuit die not contacted by the mold surface, the wire bonds, and the surfaces of the lead frame overlying the mold cavity.

25 Also formed from a portion of lead frame 108 is an electrostatic discharge ring. The electrostatic discharge ring is formed by folding a portion of the lead frame 108 from the bottom of integrated circuit die 104 and plastic or epoxy
30 material 112 up around the sides and over a peripheral portion of the top surface. Lead frame 108 is stamped with portions

preformed for folding over the sides and top during lead frame trim and form operations.

After packaging is completed, lead frame 108 includes a first portion 108a underlying the integrated circuit die 104, plastic or epoxy material 112, and bond wires 114. Much of first portion 108a comprises a die paddle to which the integrated circuit die is affixed. Second portions 108b along the sides of the integrated circuit package 102, and third portions 108c overlying a peripheral portion of an upper surface of integrated circuit package 102. (Part of the overlying peripheral portion 108c is depicted as broken-away on the left side of Figure 1A to depict pins 114). Pins 116 are also formed from portions of the stamped lead frame 108, but are, for the most part, separated from lead frame 108 during packaging trim and form operations and are held in place by plastic or epoxy material 112. At least one pin 116a (best seen in Figure 1D) remains connected to lead frame 108, serving as a ground connection for the electrostatic discharge ring. The remaining pins are, after fabrication of integrated circuit package 102 is complete, electrically and physically isolated from lead frame 108 and pin 116a, and may instead be electrically connected to the integrated circuit die 104 via bond wires 114.

As illustrated in Figure 1E, the electrostatic discharge ring formed by the folded portions of lead frame 108b and 108c may extend along a peripheral edge 118a of packaged integrated circuit 102 which is opposite pins 116, with an opening

through the folded lead frame portions 108b and 108c allowing access to pins 116 for an external connector. Alternatively, the electrostatic discharge ring may contain a broken region along a peripheral edge 118b opposite pins 116. The required length of the pins which must remain exposed for a connector, the thickness of the integrated circuit 104 and plastic or epoxy material 112, and other design considerations may affect whether the electrostatic discharge ring extends along a complete circumference of the packaged integrated circuit 102.

Referring to **Figures 2A** through **2D**, various views of alternative designs for a packaged surface mount integrated circuit having an integral electrostatic discharge ring formed from lead frame portions in accordance with a preferred embodiment of the present invention are illustrated. While the embodiment of **Figure 1A** through **1E** included straight pins for connection of the packaged integrated circuit to an external connector receiving the pins, the embodiments of **Figures 2A** through **2D** include gull wing leads for mounting the packaged integrated circuit on a printed circuit board with soldered connections.

Figure 2A is a plan view of one alternative embodiment of a packaged surface mount integrated circuit having an integral electrostatic discharge ring formed from lead frame portions, while **Figure 2B** is a cross-sectional view of the same alternative embodiment taken at section lines B-B. Packaged integrated circuit 202a includes an integrated circuit die 204 containing sensor circuitry and including a sensor surface 206. Integrated circuit die 204 is affixed on a bottom surface to lead frame 208 by an adhesive 210, and is partially

encapsulated on remaining surfaces by a plastic or epoxy material 212, but not over sensing surface 206. Plastic or epoxy material 212 also encapsulates bond wires 214 electrically connecting the integrated circuit die 204 to the leads 216.

While the embodiment of **Figures 1A** through **1E** included (or could have included) an electrostatic discharge ring along an entire circumference of an upper peripheral edge of the packaged integrated circuit, the length of lead frame material required to form gull wing leads 216 and the thin dimension of the packaged integrated circuit in the embodiment of **Figures 2A** through **2D** prevents the electrostatic discharge ring from extending all the way around the packaged integrated circuit 202a. Nonetheless, portions 208b and 208c of the lead frame 208 are folded up around the sides and over a peripheral top portion of packaged integrated circuit 202a wherever possible to form an incomplete "ring" connected to ground and dissipating electrostatic charge when contacted by a human finger.

Figure 2C is a plan view of another alternative embodiment of a packaged surface mount integrated circuit having an integral electrostatic discharge ring formed from lead frame portions, while **Figure 2D** is a cross-sectional view of that alternative embodiment taken at section lines C-C. While the embodiment shown in **Figures 2A** and **2B** includes wire bonds 214 within plastic or epoxy material 212 on only one side, the packaged integrated circuit 202b of **Figures 2C** and **2D** includes bond wires 214 encapsulated by plastic or epoxy

material 212 on both sides. Either structure may be formed in the present invention.

5 With reference now to **Figures 3A and 3B**, plan views of
lead frame strips utilized in forming a packaged surface mount
integrated circuit having an integral electrostatic discharge
ring formed from lead frame portions in accordance with a
preferred embodiment of the present invention are depicted.
The uncut lead frame strip 300 depicted in both **Figure 3A and**
10 **3B** contains a plurality of lead frames with integral electro-
static discharge ring portions for packaging integrated
circuits. Each lead frame includes a die paddle 302 to which
the integrated circuit die is affixed. Sections 304 of the
lead frame will form the electrostatic discharge ring after
15 being folded up around the sides and over an upper peripheral
portion of the integrated circuit structure being packaged by
the lead frame.

Other portions 306 of the lead frame will form the pins
20 or leads of the finished integrated circuit package and will
be separated from the remainder of the lead frame during trim
and form operations, except for one or more pins or leads
providing a grounding connection to the lead frame and
electrostatic discharge ring. The pins or leads formed from
25 portions 306 will be held in place by plastic or epoxy
encapsulating material molded around at least parts of the
integrated circuit die mounted on the leadframe, and will be
electrically connected to the integrated circuit by bond wires
within the plastic or epoxy encapsulating material. Shorting
30 bars 308, containing "tooling" or alignment holes 310, provide
structural support for the lead frame and will be removed
during lead frame trim and form operations.

During lead frame trim and form operations, sections of each lead frames will be folded along the dashed fold lines 312 depicted in Figure 3B. These sections will be folded up around the sides and over a peripheral upper surface of the integrated circuit package to form the electrostatic discharge ring. These sections remain physically and electrically connected to the lead frame die paddle on which the integrated circuit die is mounted, and are connected through the lead frame to a grounding connection. When a human finger touches the electrostatic discharge ring formed from these folded section in contacting the sensing surface of the packaged integrated circuit, any electrostatic charge is dissipated to ground by the electrostatic discharge ring.

Referring to Figures 4A-4C, various views of a narrow-strip packaged integrated circuit with gull-wing leads and an integral electrostatic discharge ring formed from lead frame portions in accordance with a preferred embodiment of the present invention are illustrated. Figure 4A shows a plan view of narrow-strip packaged integrated circuit 402, while Figure 4B shows a side view and Figure 4C shows a cross-sectional view taken at section lines D-D. Packaged integrated circuit 402 includes an integrated circuit die 404 having a sensing surface 406 mounted on a lead frame 408 with an adhesive 410. Plastic or epoxy material 412 encapsulates portions of integrated circuit die 404 other than sensing surface 406 and wire bonds 414 connecting integrated circuit die 404 to leads 416. Leads 416 are formed from portions of lead frame 408, but are separated from lead frame 408 during lead frame trim and form operations, except for one lead

providing a grounding connection for lead frame 408 and the electrostatic discharge ring.

5 Portions 408b and 408c of the lead frame 408 projecting from a bottom portion 408a are folded up around the sides of the package (portions 408c) and bent over to be level with an upper surface of plastic or epoxy material 412. These portions 408b and 408c form an electrostatic discharge "ring" for packaged integrated circuit 402 by providing a low
10 resistance path to ground. Because of the narrowness of the package and the required length of leads 416, the electrostatic discharge "ring" is formed only along the long edges of package 402, and not on the ends. However, the portions 408b and 408c of lead frame 408 which form the electrostatic
15 discharge protection are close enough to the exposed sensing surface of the packaged integrated circuit to be contacted when a finger touches the sensing surface.

20 In the present invention, an electrostatic discharge ring for packaged integrated circuits is integrally formed from a portion functions by creating a path for accumulated electric charge to flow from the human finger or other item touching the packaged device to ground. Because the electrostatic discharge ring presents a low resistance path relative to the
25 sensor area and the packaging materials, the electrostatic discharge ring serves as the preferred path from a region of high charge to a grounded region. Therefore, when a user of the sensor touches the sensor area, the user's finger will contact or come in close proximity with the electrostatic
30 discharge ring, at which time any excess charge accumulated on the user will pass through the electrostatic discharge ring to ground, protecting the integrated circuit within the package.

While the invention has been particularly shown and described with reference to a preferred embodiment, it will be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention.